

tact with a given surface is considered more in detail ; and it is shown how in general such a quadric degenerates into the tangent plane taken twice. To this there is apparently an exceptional case, the condition for which is given and reduced to a comparatively simple form ; but I must admit to having so left it, in the hope of giving a fuller discussion of it on a future occasion.

The subject of three-pointic superficial contact was considered by Dupin, ‘*Développements de Géométrie*,’ p. 12 ; and, as I have learnt since the memoir was written, a general theorem connecting superficial contact and contact along various branches of the curve of intersection of two surfaces (substantially the same as that given in the text) was enunciated by M. Moutard*.

In a corollary to this theorem, M. Moutard states that through every point of a surface there can be drawn twenty-seven conics, having six-pointic contact with the surface. This number is perhaps open to question ; and I have even reason to think, from considerations stated to me by Mr. Clifford, that the number ten given in my memoir above quoted may be capable of reduction by unity to nine. But this question refers to the subject of that earlier memoir rather than to this.

II. “On a New Hygrometer.” By WILDMAN WHITEHOUSE, Esq. Communicated by Sir W. THOMSON, F.R.S. Received January 6, 1872.

The use of Mason’s wet-bulb thermometer as a means of hygrometric measurement, though it be admitted to be the most practically useful, and indeed the only recording instrument for the purpose, has yet this serious inconvenience, not to say defect, viz. that its indications either cease or are valueless at temperatures below 32° F.

In a conversation which the writer had with the Director of the Meteorological Office some months ago, the question arose whether any thing could be suggested to remedy this inconvenience.

It was obviously inadmissible to substitute any other fluid for, or to make any addition to, the water employed for the wet bulb, as then it would cease to be a test for the purely hygrometric capacity of the air. It became therefore necessary to fall back in another direction, and to find some hygrometric body which should readily and rapidly absorb moisture from the air, and at the same time afford some means of measuring and recording the amount of such absorption.

Fused chloride of zinc or of calcium seemed promising as very active agents, absorbing rapidly on their surface, and allowing the readiest possible escape of the fluid hydrate for measurement ; yet no means presented itself either of accurately measuring, regulating, or maintaining the exact extent of surface exposed for absorption ; nor could the substance itself be

* Poncelet, ‘*Applications d’Analyse à la Géométrie*,’ 1864, tom. ii. p. 363.

easily renewed when required, nor, indeed, could either of these substances be regarded as wholly free from the interference of frost, as the moisture absorbed from the atmosphere at a temperature much below freezing-point may remain frozen on the surface, and become incapable of continuous measurement. It seemed essential to the accuracy and practical utility of any instrument designed for this purpose :—

1st. That a fixed and invariable extent of surface should at all times be exposed for absorption of moisture ;

2nd. That the apparatus should be simple, inexpensive, and not inconvenient in use ;

3rd. That the hygrometric substance should be continuously and steadily renewable ; and above all, if it were possible,

4th. That the measurement should be effected thermometrically.

No solid hygrometric substance seemed capable of meeting these requirements ; but all the conditions seemed likely to be fulfilled by the use of concentrated sulphuric acid. This would admit of being spread in an exquisitely fine film over the surface of the bulb of a thermometer by means of a glass capillary siphon, of which one end should rest on the upper part of the bulb, while the other end dipped into a reservoir of the acid. A continuous supply could be maintained for any required length of time by suitable arrangements. The absorption of moisture would necessarily be attended by a rise in temperature, and this would be proportioned to the amount of hygrometric moisture absorbed ; while the hydrated acid, having fulfilled its office, would fall in drops from the bulb into any tube or reservoir placed for the purpose.

An instrument has been constructed by the writer to test this principle, which has, by the courtesy of the Director of the Meteorological Office, been under observation for some weeks.

It consists essentially of three thermometers of similar construction, and used as a “ wet bulb,” a “ dry bulb,” and an “ acid bulb,” respectively, placed side by side on a suitable frame, and read together for comparison.

The experience already gained in the use of this instrument has shown that, with a reservoir of proper construction, the supply of acid may be made continuous for any required length of time, and that, from the very slight variations of flow which occur in its action, the supply to the thermometer will be sensibly equable.

The length of the siphon, and the size of the capillary bore, together with the difference of level between the surface of the fluid in the trough of the reservoir and the point of delivery on the bulb, will determine the rate of supply of the acid.

It is clear that either a too rapid and continuous stream of acid at the temperature of the air, or a too scanty supply, would diminish the readings ; yet it is found that practically there may be a pretty wide range of variation in the supply of acid, within which no essential change in the sensibility of the instrument is noticed.

For a bulb having one square inch of surface one drop per minute is sufficient, though the time may range from 40 to 100 seconds without inconvenience, the time being noted as the hydrated acid, after having fulfilled its office, falls drop by drop from the bulb.

The quantity of acid required at this rate is about 3 fluid ozs. per diem, or one imperial pint per week, which is procurable of uniform density, sufficiently pure and free from lead, at a cost of about $2\frac{1}{2}d$.

The temperature of the acid in the reservoir is of course that of the surrounding air; the elevation of temperature shown by the acid-bulb thermometer is due to, and seems to be strictly a measure of, the amount of moisture absorbed by the film of acid spread on the surface of the bulb, say one square inch, continuously supplied in its concentrated state, and as constantly passing off hydrated.

While, therefore, this instrument is, like Mason's, intended to measure the amount of hygrometric moisture in the air, and to do so thermometrically, it yet is, in its principle and in its operation, essentially of an opposite character.

The ordinary wet-bulb thermometer is at the zero of its scale in an atmosphere of perfect saturation, and its action depends upon the amount of sensible heat absorbed and rendered latent by evaporation of the water from its surface.

The acid-bulb thermometer is at its zero in a perfectly dry atmosphere, and its action depends upon the amount of latent heat rendered sensible by the condensation of vapour into water on the surface of the bulb, and by the combination of this water with the concentrated acid.

It would appear that an hygrometer on this principle is entirely free from the action of frost; while its sensibility is so great as to be at first almost embarrassing.

This may, however, be easily regulated and toned down, if necessary, to any required range by the dilution of the acid with glycerine, a fluid which is also of itself hygrometric, though its thermal effects are far less marked than those of sulphuric acid.

The following series of observations, made hourly and otherwise, at intervals during the past few weeks, at the Meteorological Office, by the kindness of the Director, will suffice to show approximately the relations of the "acid" and the "wet bulb" respectively.

They have been chiefly actual out-door observations, and have extended over a considerable range of temperature and atmospheric variations.

It will require a most careful series of observations to elicit all the points noteworthy in the new instrument, and to determine the relative values of the wet and acid-bulb readings, noting the behaviour of each at every part of the scale, from absolute dryness to saturation, and at temperatures ranging from 75° or 80° down to 0° .

This will be necessary before the instrument can aspire to take its place among the recognized standards of meteorological science; but in the

mean time the writer has been advised to offer, at the earliest time, a brief description of it to the notice of the Royal Society.

TABLE.—Giving comparison of Readings of Wet- and Acid-bulb Hygrometers.

1871.		Mason's Hygrometer.			Mr. Whitehouse's.		Deductions from Wet-bulb Hygrometer.			Remarks.
Day.	Hour.	Dry Bulb.	Wet Bulb.	Difference, D-W.	Acid Bulb.	Difference, A-D.	Tension of Vapour.	Weight of Vapour in 1 cub. foot of Air.	Relative Humidity. Saturation = 100.	
	Acid flow h. m.	ing	from	bulb	1 drop	in 33 seconds.				
Nov. 6	10 7 A.M.	40'0	36'0	4'0	60'2	20'2	172	2'0	69	At noon the wet bulb was washed and resupplied with water. Sky has gradually become overcast since the morning.
"	10 30 "	40'5	36'3	4'2	61'5	21'0	173	2'0	69	
"	11 25 "	41'0	36'7	4'3	61'3	20'3	175	2'0	68	
"	11 33 "	41'0	37'0	4'0	62'0	21'0	180	2'1	70	
"	1 4 P.M.	43'0	38'0	5'0	64'0	21'0	181	2'1	65	
"	1 50 "	44'0	38'5	5'5	65'2	21'2	180	2'1	62	
"	2 5 "	44'0	39'0	5'0	65'3	21'3	188	2'2	65	
"	2 20 "	43'7	38'8	4'9	65'9	22'2	188	2'2	66	
"	2 30 "	44'0	39'0	5'0	65'7	21'7	188	2'2	65	
"	3 30 "	44'0	39'3	4'7	66'3	22'3	193	2'3	67	
"	3 55 "	44'0	39'6	4'4	67'0	23'0	198	2'3	68	
Nov. 7	9 45 A.M.	45'0	43'0	2'0	75'0	30'0	253	2'9	85	Note the change in night! Dark and foggy day. (!)
"	10 10 "	45'5	44'0	1'5	77'8	32'3	270	3'1	89	
"	10 20 "	46'0	44'2	1'8	76'0	30'0	269	3'1	87	
"	10 30 "	46'0	44'2	1'8	76'2	30'2	269	3'1	87	
"	11 5 "	46'8	45'0	1'8	75'2	28'4	277	3'1	87	
"	11 35 "	47'7	45'6	2'1	78'0	30'3	276	3'2	87	
"	1 15 P.M.	50'0	47'0	3'0	82'0	32'0	286	3'3	80	
"	3 15 "	50'0	47'0	3'0	82'4	32'4	286	3'3	80	
"	3 50 "	50'0	47'0	3'0	82'9	32'9	286	3'3	80	
"	4 0 "	50'0	47'0	3'0	83'0	33'0	286	3'3	80	
"	5 0 "	49'5	46'5	3'0	83'5	34'0	281	3'2	80	Vapour has increased, but humidity has decreased. (!)
"	6 0 "	49'5	46'5	3'0	82'5	33'0	281	3'2	80	
"	8 0 "	51'0	47'0	4'0	81'5	30'5	276	3'1	74	
"	9 0 "	49'5	46'0	3'5	79'5	30'0	270	3'0	76	
Nov. 8	10 40 A.M.	47'5	45'5	2'0	81'8	34'3	280	3'3	86	
"	10 50 "	50'3	48'0	2'3	89'0	38'7	305	3'5	84	
"	11 15 "	50'0	47'6	2'4	88'0	38'0	300	3'4	83	
"	11 25 "	50'0	47'0	3'0	85'3	35'3	286	3'3	80	
"	NOON	50'3	47'0	3'3	82'0	31'7	283	3'3	78	
"	1 50 P.M.	51'0	45'5	5'5	81'0	30'0	246	2'8	63	
"	2 30 "	49'7	43'0	6'7	75'2	25'5	210	2'4	59	Sky clearing since 11.25 A.M. Humidity greatly reduced; vapour not so much. Vapour decreased in greater proportion than humidity.
"	3 0 "	49'0	43'2	5'8	76'0	27'0	221	2'5	63	
"	3 50 "	48'7	43'0	5'7	74'7	26'0	219	2'5	66	

TABLE (continued).

1871.		Mason's Hygrometer.			Mr. Whitehouse's.		Deductions from Wet-bulb Hygrometer.			Remarks.
Day.	Hour.	Dry Bulb.	Wet Bulb.	Difference, D-W.	Acid Bulb.	Difference, A-D.	Tension of Vapour.	Weight of Vapour in 1 cub. foot of Air.	Relative Humidity. Saturation = 100.	
Nov. 9 ..	h. m. 9 0 A.M.	37°0	35°0	2°0	58°5	21°5	182	2'1	83	{ Vapour much decreased; yet humidity has risen. Note acid-bulb. Fine day; rather cloudy P.M. Vapour slightly increased, but humidity decreased. Note acid-bulb.
" ..	9 10 "	37°0	35°0	2°0	58°0	21°0	182	2'1	83	
" ..	0 20 P.M.	45°0	40°0	5°0	68°0	23°0	197	2'3	66	
" ..	2 0 "	45°0	39°2	5°8	66°0	21°0	184	2'1	61	{ Slight shower at 4.10 P.M.
" ..	3 0 "	45°0	39°0	6°0	66°7	21°7	181	2'1	60	
" ..	3 30 "	45°0	39°2	5°8	66°0	21°0	184	2'1	61	
" ..	3 45 "	44°5	39°0	5°5	65°7	21°2	185	2'1	63	{ Note these changes.
" ..	6 0 "	42°0	38°5	3°5	63°5	21°5	198	2'3	76	
" ..	6 30 "	42°0	38°5	3°5	62°5	20°5	198	2'3	76	
" ..	7 0 "	41°0	38°0	3°0	62°0	21°0	197	2'3	77	{ Foggy and cold.
" ..	8 0 "	39°5	37°0	2°5	63°0	23°5	194	2'3	80	
" ..	9 0 "	39°5	36°5	3°0	61°0	21°5	185	2'1	77	
Nov. 10..	11 30 A.M.	43°0	39°0	4°0	67°0	24°0	181	2'1	65	{ Vapour increased; humidity steady.
" ..	11 40 "	42°5	39°0	3°5	67°2	24°7	202	2'3	75	
" ..	3 10 P.M.	45°0	39°0	6°0	68°0	23°0	181	2'1	60	
" ..	6 0 "	42°5	37°0	5°5	62°0	19°5	170	1'9	63	{ Acid-reading doubtful; taken too soon after starting.
" ..	6 30 "	41°5	37°0	4°5	61°0	19°5	177	2°0	67	
" ..	7 30 "	40°0	36°5	3°5	60°0	20°0	180	2°1	73	
" ..	8 0 "	39°5	36°0	3°5	61°0	21°5	176	2°1	74	{ Humidity unaltered; vapour decreased.
" ..	8 30 "	38°5	35°5	3°0	60°0	21°5	177	2°1	76	
" ..	9 0 "	38°5	35°0	3°5	59°5	21°0	169	2°0	80	
Nov. 11..	8 50 A.M.	33°0	32°0	1°0	52°5	19°5	167	2°0	89	{ Vapour increased; humidity steady.
" ..	9 50 "	35°0	33°0	2°0	55°0	20°0	164	1°9	80	
" ..	11 20 "	39°0	36°5	2°5	62°0	23°0	190	2°2	80	
Nov. 4 ..	Acid flow ing about 1 drop in 77 seconds.									{ Acid-reading doubtful; taken too soon after starting.
" ..	2 50 P.M.	48°0	44°5	3°5	71°5	23°5	253	2°9	76	
" ..	3 10 "	47°3	44°0	3°3	74°3	27°0	258	2°9	77	
" ..	3 30 "	47°5	44°3	3°2	75°0	27°5	255	2°85	78	{ Humidity unaltered; vapour decreased.
" ..	3 50 "	47°2	44°0	3°2	74°0	26°8	251	2°9	78	
Nov. 24..	11 24 A.M.	44°0	41°2	2°8	66°5	22°5	228	2°6	78	
" ..	5 30 P.M.	42°0	38°5	3°5	63°3	21°3	199	2°3	75	{ Vapour hardly changed; humidity very largely increased. Note acid.
" ..	6 0 "	41°5	38°0	3°5	63°0	21°5	193	2°3	75	
" ..	6 30 "	41°5	37°5	4°0	63°0	21°5	185	2°2	71	
Nov. 25..	11 30 A.M.	38°5	36°8	1°7	61°0	22°5	200	2°3	86	{ Vapour hardly changed; humidity very largely increased. Note acid.
Nov. 29..	11 15 "	39°0	37°0	2°0	61°5	22°5	199	2°3	84	
" ..	11 25 "	39°0	37°0	2°0	61°0	22°0				
" ..	3 45 P.M.	40°0	37°3	2°7	62°5	22°5				{ Raining.
" ..	5 0 "	39°0	37°5	1°5	61°0	22°0				
" ..	6 0 "	38°0	36°0	2°0	59°0	21°0				
" ..	6 30 "	38°0	35°5	2°5	58°5	20°0				{ Raining.
Nov. 30..	2 0 "	39°0	37°0	2°0	62°0	23°0				
" ..	4 0 "	39°5	37°0	2°5	61°5	22°0				
" ..	4 30 "	39°0	37°0	2°0	61°5	22°5				{ Raining.
" ..	5 0 "	38°5	37°0	1°5	61°0	22°5				
" ..	5 30 "	38°5	36°7	1°8	61°0	22°5				